Biogas to Vehicle Fuel Project

Rodefeld Landfill
Dane County, Wisconsin

Presented by:
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March 23, 2011
Wichita, Kansas

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Biogas Vehicle Fuel Project

- Dane County, Wisconsin Rodefeld Landfill
- Developed with private, municipal and educational entities
- Purpose is to use biogas as a vehicle fuel on a small scale (100 gge/d)
- System installation - December 23, 2010

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Overview of Biogas and Utilization as a Vehicle Fuel

- Biogas : Landfills, WWTP, Digesters
- National: CA, OH
  - Altamont Landfill - LNG California, 3,000 scfm, $15.5MM
  - SWACO Landfill - CNG Ohio, 200 scfm, $4MM
- Small Scale System Availability?
  - Can small biogas to vehicle fuel systems be cost effective?

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The Anaerobic Decomposition Process

Organic Matter "WASTE" → Acid Forming Bacteria → Organic Acids (Acetic Acid) CH_3COOH → Methane Forming Bacteria

CH_4 + CO_2 + Heat

50 to 65% 35 to 50%

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Over 12,000,000 CNG vehicles in use worldwide and growing!

Source NGV America

Manufactures are Incorporating CNG into Vehicles

Dual Fuel CNG / Gasoline VW Passat

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CNG Waste Truck

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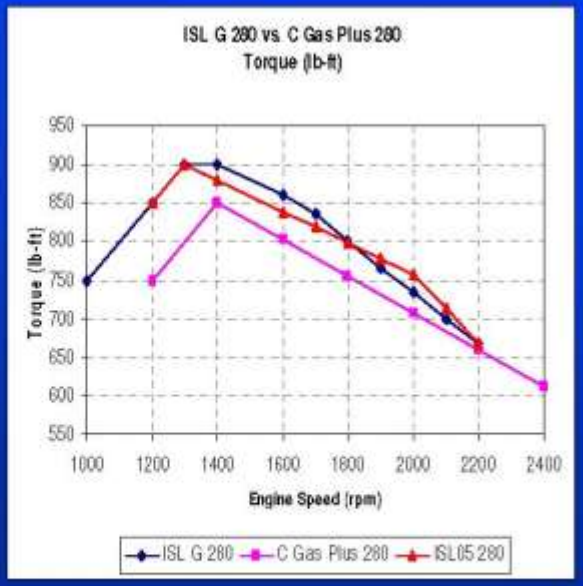
Cummins Westport Inc

8.9L ISL-G (in-line 6c, 2200 rpm engine)

- Stoichomteric combustion w EGR+3-way cat
- .2 NOx/.01 PM – 2010 compliant)
- Engine Ratings

Model	Horsepower	Peak Torque
320	320 @ 2200	1000 @ 1300
300	300 @ 2100	860 @ 1300
280	280 @ 2000	900 @ 1300
260	260 @ 2200	660 @ 1300
250	250 @ 2200	730 @ 1300



- Refuse collection trucks
  - Crane Carrier LET, Autocar Xpeditor, Peterbilt LCF 320, Int'l/ALF Condor, Mack TerraPro LE;
- Work /Vocational Trucks
  - Freightliner M2-112; Kenworth T8SH and T440; Peterbilt 365 and 384;

Source NGV America

Project Considerations

- Evaluate biogas clean-up technologies
  - resulted in Patent Pending process
- Viability using biogas as a vehicle fuel as an add-on to an existing 6.4 MW LFGTE System
- As fuel demand grows blend natural gas and BioCNG (similar to biodiesel and ethanol)

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Biogas Treatment Requirements / Considerations

- Moisture removal (to -40 F at 4000 PSIG)
- Hydrogen Sulfide removal
- VOC / Siloxane removal
- CO_2 removal
- Fuel requirements:
  - Engine Manufacturers Specifications, SAE J1616

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Ford 1998 CNG / Gasoline Pickup Truck
Purchased By Dane County February 22, 2010

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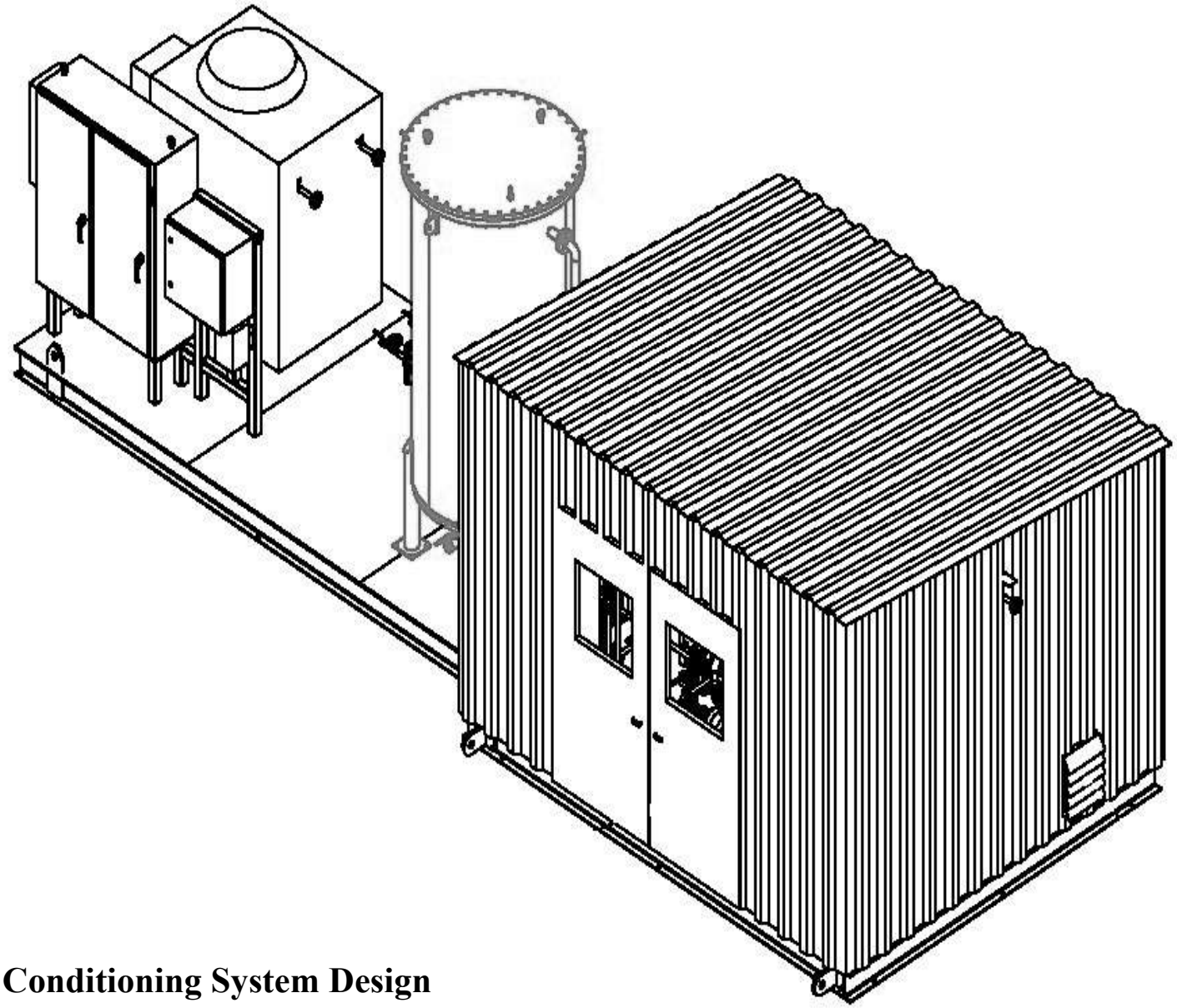

BioCNG Conditioning System Design
Completed September 2010

Fabrication at Unison Solutions
Dubuque, Iowa
December 7, 2010

System Delivery December 23, 2010

System mechanical and electrical connections completed December 27, 2010

System Startup December 28, 2010

Fueling Station, Fast Fill 60-GGE capacity

First Vehicle Fueled March 18, 2011

Rodefeld Landfill / BioCNG Gas Constituents

Constituent	Units	Inlet LFG	BioCNG
CH_4	vol. %	55.0	90.0
CO_2	vol. %	39.5	0.3
O_2	vol. %	0.5	0.1
N_2	vol. %	5.0	9.6
H_2S	ppmv	250	ND

Notes:

(1) Data is compiled from field and laboratory analysis of samples collected on January 4, 2011.
(2) Cummins ISL G engine specifications call for a minimum methane number of 75 CH4

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BioCNG Economic Considerations

- Is biogas of suitable quality available?
- Base value on off-setting diesel, gasoline, natural gas or natural gas CNG?
- Alternate vehicle fuel incentives or grants?
  - $0.50 / GGE federal tax credit (Equivalent to $.04/KWh)
- Value placed on environmental / sustainability attributes?
- Number of CNG vehicles to use fuel?
- BioCNG for sale or own use?

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Project Economics

- 100 GGE/day replacing gasoline at $3.50/gal
  - $110,000 / year avoided cost
- As demand for gas increases natural gas can be blended at 10% BioCNG = 1000 GGE/day
- BioCNG production $0.50 to $1.00 / GGE
- Approximate 20 scfm System Cost
  - $300,000 for gas conditioning skid
  - $55,000 for CNG fueling station

(Actual site conditions and SCFM will dictate System Cost)

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What will be learned from the Project

- **Is BioCNG a reliable vehicle fuel ?**
- **Ease of production / blending?**
- **BioCNG production costs ?**
- **Will staff use CNG vehicles ?**
- **Public perception of BioCNG?**

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